4.14 System Engineering Process Management

4.14.1 Introduction

The Federal Aviation Administration (FAA) promotes use of the standard System Engineering (SE) processes. The processes must be continuously monitored and improved to optimize performance and ensure quality. These are institutionalized via the System Engineering Manual (SEM) and associated SE training courses. The System Engineering Council (SEC) owns and promotes use of standard SE processes and is responsible for maintaining and improving them. Figure 4.14-1 depicts the SE Process Management process.

It is recommended that the implementing organization tailor the guidance contained in this SEM to support SE process implementation. Tailoring guidance appears in subsection 4.14.6.

Process:

Perform System Engineering Process Management

ID No.: 4.14 (iCMM PA 21, 22, 23
Date: April 25, 2000
Revision Date: August 30, 2006

Next Higher Level Process:
Perform System Engineering

Process Owner:
System Engineering Council

Process Objective:
Maintain and improve SE processes contained in SEM; Train the workforce on SE process; Incorporate process innovation.

Inputs

a) SE comments
b) Other FAA processes
c) Standards
d) SE Training Feedback
e) Technical and Program Products
f) Process Assessment Requests
g) FAA SE Competency Needs
h) SE Processes, SE Best-Practices Document (SEM), SEBOK

Providers

a) EXT
b) EXT
c) EXT, SE
d) EXT
e) EXT
f) EXT
g) EXT
h) MSE

PROCESS TASKS

Beginning Boundary Task
Define & document SE Standard processes

- Manage SE Standard processes
- Evaluate & Monitor present SE implementation performance
- Define improvements

Ending Boundary Task
Implement improvement

Lifecycle Phase

- ☑ Mission Analysis
- ☑ Investment Analysis
- ☑ Solution Implementation
- ☑ In-Service Management
- ☑ Disposal

Outputs

a) SE Processes
b) SE Best-Practices Documentation (SEM)
c) SEBOK (e.g., lessons learned, templates, examples)
d) SE Training Curriculum Skill and/or Competency Requirements

Customers

a) EXT, ITP, RM, FA, SYN, TS, IM, SpecEng, IA, RSK, CM, V&V, LCE
b) EXT, ITP, RM, FA, SYN, TS, IM, SpecEng, IA, RSK, CM, V&V, LCE
c) SE, EXT
d) EXT, ITP, RM, FA, SYN, TS, IM, SpecEng, IA, RSK, CM, V&V, LCE

Figure 4.14-1. System Engineering Process Management Process-Based Management Chart

4.14.2 Objectives of System Engineering Process Management

The objectives are:

- Maintain and improve SE processes contained in the SEM
- Manage the SE training curriculum and course content to ensure that they accurately reflect the processes in the SEM
- Sponsor training for the workforce on the FAA SE processes
- Incorporate process innovation

4.14.3 Inputs

System Engineering Process Management acquires information from various sources to improve the SE processes and/or related materials.

4.14.3.1 System Engineering Feedback

Feedback on SE process elements from internal FAA stakeholders, process implementers, business partners, and external SE organizations—such as the International Council on Systems Engineering—is a primary input to SE process management.

4.14.3.2 Other FAA Processes

Processes within the FAA (e.g., the Acquisition Management System (AMS)) may have an impact on the SE process and may also mandate additional process metrics.

4.14.3.3 Standards

Standards issued by government agencies (e.g., Office of Management and Budget and National Institute of Standards and Technology) and industry trade groups (e.g., Institute of Electrical and Electronics Engineers, Inc., and International Council on Systems Engineering) may be mandated, or they may be adopted for incorporation within the FAA SE process to enhance quality and visibility.

4.14.3.4 System Engineering Training Feedback

Written and oral student critiques on the SE training courses are used as a basis for refining the SE training materials and curriculum. Attendance numbers and course demand information are collected from the instructors in accordance with SEC Standard Training Operating Procedures to determine the future direction of the training effort.

4.14.3.5 Technical and Program Products

National Airspace System (NAS) SE products specified within the individual SE elements described in this document and related program implementation lessons learned are reviewed to develop and maintain SE best practices for FAA implementation. These include, but are not limited to, requirements documents such as Interface Requirements Documents, organizationally tailored SEMPs, and NAS Architecture work products. In addition, these

products are used for the Technical Control and Monitoring portion of Integrated Technical Planning (Section 4.2) to assess the progress and maturity of FAA investments.

4.14.3.6 Process Assessment Request Responses

Responses to Process Assessment Requests will be periodically reviewed as submitted by FAA organizations that use SEM processes. The results are evaluated to develop a lessons learned repository to support the FAA and to adjust the processes in the SEM accordingly.

4.14.3.7 FAA SE Competency Needs

FAA-wide assessments of current and future need for SE Core Competencies are factored into enhancement of SE processes. These interdisciplinary SE resources of SE knowledge include coverage of Systems Thinking, Holistic Lifecycle View, and SE Management within the context of FAA systems. Once the shortfalls in required SE competencies, skill sets, and domain knowledge have been identified, the SEC develops a plan for eliminating shortfalls through process improvement (e.g., updates to SEM and associated training materials), internal training, mentoring, continuing education, and certification.

4.14.4 Process Steps

4.14.4.1 Define and Document SE Standard Processes

The SEM is the documented source of FAA SE processes approved by the SEC. The SEM explicitly describes the processes in a prescribed format using standard SE tools and techniques (e.g., process-based management charts and an N-squared chart).

4.14.4.2 Manage SE Standard Processes

These processes are managed as versions of the SEM and reflected in SEC-sponsored, FAA-specific SE training. Updates to the SEM, which incorporates approved updates to SE processes, are configuration controlled. The latest version is available online. FAA organizations may consider tailoring these processes during various phases of the system lifecycle. Subsection 4.14.6 describes a balanced tailoring approach. It involves an awareness of mission, environmental, and supplier constraints (e.g., standards and other FAA processes) to craft acceptable efficiencies into the nominal, rigorous process.

4.14.4.3 Evaluate and Monitor Present SE Implementation Performance

Feedback from practitioners will be solicited and evaluated to assess the effectiveness of the SE process implementation. SE products produced by services/teams implementing the FAA SEM will be reviewed to identify potential improvements for SE processes. These products will also be examined to identify implementation improvements.

Every 3 years, the SEC shall perform a detailed evaluation of the FAA SE processes and their implementation, using appropriate standard assessment models (e.g., Electronics Industries Alliance (EIA)-731 or iCMM (integrated Capability Maturity Model)). Service organizations may also request an evaluation of their tailored processes through a Process Assessment Request.

4.14.4.3.1 SE Training Evaluation

SE training feedback (e.g., number of students trained, student evaluations of the courses, and assessments of applicability of course material to FAA organizations) is evaluated to assess SE training effectiveness across the FAA and to influence the future needs for the SE training curriculum. Development of the course curriculum and materials and updates are based on these evaluations.

4.14.4.3.2 Required SE Capabilities

The key set of capabilities required to perform sound system engineering of the NAS is identified using the FAA SE Competency Needs. These capabilities are as follows:

- **Competency Description.** This is a refined elaboration of the SE areas of understanding described in subsection 4.14.3.7
- **Relevance.** This is a description of why this competency is significant for the target domain within the FAA.
- **Knowledge and Experience Level Criteria.** This describes the minimum conditions of maturity in that competency for various levels of expertise (e.g., awareness, supervised practitioner, practitioner, and expert).

Additionally, the availability of FAA SE resources are evaluated, focusing on levels of proficiency regarding:

- **SE Knowledge.** These are skills and techniques required to perform SE tasks (e.g., Failure Analysis, Safety Analysis, and Human Factors).
- **Basic Skills and Behaviors.** These are skills expected from a professional engineer (e.g., communication skills, teamwork, coaching).
- **Domain Knowledge.** This is knowledge of the NAS or other specific niche areas relevant to FAA mission needs.

This evaluation will be used to determine required training, continuing education, mentoring, hiring, and/or certification requirements.

4.14.4.4 Define Improvement

Once a need for improvement is determined, the appropriate SE process documentation shall be analyzed (e.g., the SEM and associated training materials) to determine what specific changes must be made. The SEC is responsible for improvements to SE processes as documented in the SEM and SE training materials.

4.14.4.5 Implement Improvement

The SEC shall use Standard Operating Procedures (SOP) to implement improvements and annual SE Process Improvement objectives. These SOPs ensure a consistent, formal method of process improvement.

4.14.5 Outputs

4.14.5.1 SE Best Practices Documentation

SE best practices are documented and distributed to maintain state-of-the-art SE capability in the FAA domain. Interim updates to SE processes, or improved tailoring of such processes, may be issued on an ad hoc basis. Following are examples of specific artifacts.

4.14.5.1.1 SEM Updates

New editions of the SEM are released when a revision is necessary and upon SEC approval of the incorporated SE process changes, SEM comments, and updates.

4.14.5.1.2 NAS SEMP Updates

The NAS SEMP is updated and published as necessary. This plan documents the organizations responsible for performing the SE tasks in the SEM. A program uses the NAS SEMP until the program SEMP is developed. For additional information, see Integrated Technical Planning (Section 4.2).

4.14.5.2 SE Body of Knowledge (SEBOK)

A comprehensive FAA SEBOK features the following:

- A central knowledge base for acquiring, defining, and disseminating guidance for FAA SE processes
- Reduction of redundant, divergent sources of SE knowledge
- A forum to share lessons learned about the application of SE in practice
- A starting point for learning about SE in the FAA

The SEBOK will be accessible across the FAA, and system engineers implementing the FAA SEM are encouraged to contribute to its content.

4.14.5.3 SE Training Curriculum

The SEC sponsors SE training to reflect the processes, techniques, and practices in the SEM. Updated SE course materials are distributed and taught by appropriate SE training course instructors based on the FAA SEM process descriptions or SE training feedback.

SE process training shall be consistent with the process implementation outlined in the SEM. Development of specific training shall be geared to user needs and governed by a 5-year (rolling) strategic SE training plan. The training material shall be configuration controlled, and the latest version maintained in the FAA SEBOK.

4.14.5.4 Skill/Competency Requirements

As a result of an evaluation of the FAA SE Competency Needs, a Competency Framework will be compiled describing a profile of required SE competencies, associated levels of expertise,

and a projected staffing level for these resources. These competencies will also be mapped to underlying Supporting Techniques capabilities required for each competency, and Basic Skills for enabling Supporting Techniques. This information will be used to assess the resources available and training requirements within the FAA SE community of interest.

4.14.6 Guidance for Tailoring System Engineering

This SEM defines the FAA SE elements and the work products generated from these elements during each AMS phase. The 12 elements appear in Chapter 1 (Table 1.2-1). A 13th element is included to provide for process management and maintenance of the other 12 elements. These defined elements are elements of better SE practices that have been designed to be tailored. Tailoring is deletion or reduction in depth of the application of any of these 12 elements. Tailoring is also the addition of unique or special-focus elements or areas provided in organization policies and procedures or in an acquirer/supplier relationship.

Whether applied to a context that deals with systems that are large or small, hardware-intensive or software-intensive, people- or process-concentrated, many if not all of the SE elements apply. The magnitude and nature of the program determine which of the elements apply, and to what depth. It is recommended that program cost/benefit considerations be the basis for the allocation of appropriate resources, including manpower and schedule, to any process activity.

Service organizations may consider tailoring these processes during various phases of the system lifecycle. A balanced tailoring approach involves an awareness of mission, objectives, and constraints (e.g., environmental, supplier, Standards, or other FAA processes). The steps for determining the criteria for tailoring at any lifecycle phase are as follows:

1. Determine process relevance to system integrity
2. Determine process relevance to cost, schedule, and risks
3. Determine the extent of review, coordination, and decision methods
4. Determine quality of documentation needed
5. Ensure that tailoring does not increase programmatic risks

Tailoring is determined by the appropriate system engineering management authority designated in the domain (or business unit)-level or Service Organization-level SEMP. It is recommended that individual programs tailor the application of processes, tools, and techniques according to program requirements, with the appropriate SE management authority directing implementation of these processes. The chief system engineer, program manager, or other duly authorized authority makes the tailoring decision and captures the rationale for eliminating or reducing the depth of each of the SE elements in the SEMP.

It is also recommended that the assumptions, bases, and rationale for tailoring SE elements be captured in the program-level, business-level, or domain-level SEMP. The intent is not to overburden the lower-than-NAS-level organizations with mandated guidance, but to give them the prerogative to exercise judgment while remaining aware of the proven practices in the FAA SEM. This principle does not mean that large, complex programs may be de-scoped, except under the ground rules listed in this section. The following subsections give examples of specific aspects of SE processes (with referenced SEM sections in parenthesis) and how they are to be treated in a tailoring effort.

4.14.6.1 Tailoring of AMS Process Phase (Chapter 3) Aspects of SE

Chapter 3 describes the AMS phases for all programs and the SE effort to support them. It is recommended that these phases **not** be eliminated or combined on any program. However, they may be shorter. Furthermore, it is recommended that the entrance and exit criteria for any phase not be ignored. In addition, the exit reviews associated with the phases are considered mandatory. "Tailoring of Review Aspects of System Engineering" (subsection 4.14.6.3 below) discusses the SE reviews associated with the AMS exit reviews.

4.14.6.2 Tailoring of Planning (Section 4.2) Aspects of SE

It is recommended that all plans pertinent to the program be written; however, some plans may be shortened to a single page or combined in a single document. When combined, the resulting document contains the rationale and the justification for the combining. The most important plan is the SEMP, the primary product of the SE element Integrated Technical Planning (Section 4.2). The SEMP may be reduced to its essential elements, and individual entries may be as short as a single line. It is recommended that the following aspects always be retained:

- AMS phases (Section 3.2)
- SE elements (Sections 4.2 through 4.14, as tailored)
- SE specialties to be employed on the program

4.14.6.3 Tailoring of Review (Subsection 4.2.6) Aspects of SE

Two rules prevail regarding this topic: (1) It is recommended that all major reviews be performed at the end of each of the AMS defined lifecycle phases, and (2) it is recommended that reviews not be combined. However, the time between the Initial Investment Decision and the Final Investment Decision could be abbreviated if all requirements are met, depending on the nature of the program/acquisition. Additionally, a review may be shortened to an hour for a simple project. The sponsor of the review confirms the basic purpose and ground rules of the review to ensure that they meet the intended purpose. Software reviews are only required if software is selected as a solution to the system requirements (discussed below in "Tailoring of Synthesis (Section 4.5) Aspects of SE" (subsection 4.14.6.6)).

4.14.6.4 Tailoring of Requirements Management (Section 4.3) Aspects of SE

Requirements Management is an example of a fundamental process, and it is recommended that its basic principles be maintained on programs of any size. On all programs, a requirements Management tool is highly recommended, and the results are loaded into a master requirements database.

4.14.6.5 Tailoring of Functional Analysis (Section 4.4) Aspects of SE

Functional Analysis is an example of a fundamental process, and it is recommended that its basic principles be maintained on programs of any size. On all programs, it is recommended that Functional Analysis be used to derive requirements in a structured and systematic method. The depth, scope, and tools used in developing the functional architecture may be tailored according to program complexity.

4.14.6.6 Tailoring of Synthesis (Section 4.5) Aspects of SE

It is recommended that Synthesis be performed to define design solutions and identify subsystems to satisfy the requirements of the verified functional architecture. Synthesis translates the functional architecture into a design architecture that provides an arrangement of system elements, their decomposition, interfaces (internal and external), and design constraints. Synthesis activities involve selecting a preferred solution or arrangement from a set of alternatives and understanding associated cost, schedule, performance, and risk implications. Depending on the type of acquisition involved (e.g., commercial-off-the shelf (COTS) items, non-developmental items, commercial hardware/developed software, and a mix of solution processes), every aspect of synthesis need not be performed, or the depth of every aspect that is performed need not be extensive.

Software is often the preferred solution to system (i.e., hardware and software) requirements. If software is required, standard software reviews and documentation are required. However, it is **not** to be assumed that, if a program is designated as a software program, then the total system aspects of SE might be ignored.

4.14.6.7 Tailoring of Risk Management (Section 4.10) Aspects of SE

Risk Management is to be performed on programs of any size and throughout the lifecycle. The Risk Management process is extremely practical and adaptable to programs of any size. It is recommended that the tailoring for this process element adapt the basic process model to the program or organizational objectives. The tailoring focuses on the extent and depth that Risk Management is to be implemented, the tools to be employed, and the management-defined reporting requirements involved. A risk database is recommended for all implementations.

4.14.6.8 Tailoring of Verification (Section 4.12) Aspects of SE

Verification is one of the SE basic principles—it is recommended that all requirements be verified. This is not to say that extensive testing is required, but simply that it is recommended that steps be taken to ensure that the solution satisfies the requirements. A simple analysis often provides that assurance. It is recommended that this principle not be compromised on small programs. Failure to verify requirements may cause small programs to turn unintentionally into large programs.

4.14.6.9 Tailoring of Lifecycle Engineering (Section 4.13) Aspects of SE

The key to a productive and cost-effective Lifecycle Engineering process is proper tailoring so that available resources are concentrated on the data that will most benefit the program. Limitations on acquisition funding require that the lifecycle engineering effort be applied selectively in order to improve hardware design and support concepts, not merely to collect data. Specific topics of consideration should include:

- Amount of design freedom involved
- Amount of funds available
- Estimated return on investment (see Investment Analysis)
- Schedule constraints (fast-track program, compressed schedule, congressional emphasis)

- Available and relevancy of existing data

Programs are tailored in several ways. Each element of Integrated Logistics Support must be analyzed to determine what level of detail is needed to identify and procure the proper level of support. The maintenance concept (organic or contractor maintenance, remove/replace, or repair at the site level); type of acquisition (COTS or developed); documentation available from the vendor; and so forth will have an impact on the level of detail needed to support an acquisition. Programs are also tailored depending on the acquisition phase.

4.14.7 References

1. Cowper, Bennison, Allen-Shalless, R. et al. *INCOSE SE Core Competencies Framework*. International Council on Systems Engineering (INCOSE), May 31, 2005.

2. *INCOSE System Engineering Handbook*. Version 3. INCOSE-TP-2003-002-03, June 2006.

3. *Systems Engineering Capability Model.* EIA-731.1. Arlington, VA: Electronics Industries Alliance, December 1998. (http://www.eia.org/)